

Hydrology is generally defined as a science dealing with the interrelationship between water on and under the earth and in the atmosphere. **For the purpose of this manual, hydrology will deal with estimating flood magnitudes as the result of precipitation.** In the design of highway drainage structures, floods are usually considered in terms of peak runoff or discharge in cubic feet per second (cfs) and hydro graphs as discharge per time. For structures which are designed to control volume of runoff, like detention storage facilities, or where flood routing through culverts is used, then the entire discharge hydro graph will be of interest.

### V-01.01 Hydrologic Design Policies

Following is a summary of policies which generally should be followed for Hydrologic analyses: [For a more detailed discussion refer to the publication, "Highway Drainage Guidelines," published by the American Association of State Highway and Transportation Officials. (AASHTO)]

- **Studies**—Since Hydrologic considerations can influence the selection of a highway corridor and the alternate routes within the corridor, studies and investigations, including consideration of the environmental and ecological impact of the project, should be undertaken. Also special studies and investigations may be required at sensitive locations. The magnitude and complexity of these studies should be commensurate with the importance and magnitude of the project and problems encountered. Typical data to be included in such studies are:
  - Topographic Maps
  - Aerial Photographs
  - Stream Flow Records
  - Historical High Water Elevations
- **Coordination**—Since many levels of government plan, design, and construct highway and water resource projects which might have an effect on each other, interagency coordination is desirable and often necessary. In addition, agencies share data and experiences within project areas to assist in the completion of accurate Hydrologic analysis.
- **Documentation**—Experience indicates that the design of highway drainage facilities should be adequately documented. Frequently, it is necessary to refer to plans and specifications long after the actual construction has been completed. Thus it is necessary to fully document the results of all Hydrologic analysis.

### V-01.02 Design Frequency

A design frequency should be selected commensurate with facilities cost, potential flood hazard to property, expected level of service (functional classification of highway or urban program), political considerations, and budget constraints. In selecting a design frequency, potential upstream land use should be considered, which could reasonably occur over the anticipated life of the drainage facility. **See Appendix V-01A for 'Highway Classification Criteria - Design Flood Frequency'.** Also, refer to the **'Functional Classification Maps'** for the rural highway system, and the **'Urban Program Maps'** for North Dakota's thirteen major cities. These maps may be obtained from the Planning Division of the North Dakota Department of Transportation.

### V-01.03 Hydrologic Analysis

#### V-01.03.1 Factors to Consider in the Analysis

The following factors should be considered in making the analysis based on the respective site conditions:

- Drainage basin characteristics including: size, shape, slope, land use, geology, soil type, surface infiltration and storage.
- Stream channel characteristics including geometry and configuration, natural and artificial controls, channel modification (deposition - erosion), ice and debris.
- Flood plain characteristics.
- All Hydrologic analyses should consider the drainage history of the area and any drainage problems relating to existing and proposed structures. This information is available within the hydraulic sections of the Design and Bridge Divisions.
- Rainfall amount and storm distribution.
- Ground cover
- Type of soil
- Prior moisture condition.
- Storage potential (overbank, ponds, wetlands, reservoirs, channel, etc.).
- Watershed development potential.
- Type of precipitation (rain, snow, hail, or combinations of these).

- Terrain

### V-01.03.2 Peak Rate of Runoff Analysis

The analysis of the peak rate of runoff, volume of runoff, and time distribution of flow is fundamental to the design of drainage facilities. Errors in the estimates will result in a structure that is either undersized and results in drainage problems, or oversized and costs more than necessary. On the other hand, it must be realized that any Hydrologic analysis is only an approximation. The relationship between the amount of precipitation on a drainage basin and the amount of runoff from the basin is complex, and too little data is available on the factors influencing the rural and urban rainfall-runoff relationship to expect exact solutions.

### V-01.03.3 100 year Frequency

Discharges for 100 year frequencies should be computed and compared to the associated high water (H W) stage elevation. These should be listed on the plans for all drainage structures 30" in diameter or larger.

### V-01.03.4 Risk Assessment

Occasionally, hydraulic analyses should include the determination of several design flood frequencies for use in the hydraulic design. These frequencies are used to size different drainage facilities so as to allow for an optimum design, which considers both risk of damage and construction cost.

### V-01.04 Hydrologic Methods

Many Hydrologic methods are available. The methods to be used and circumstances for their use are listed below. If possible the method should be calibrated to local conditions and tested for accuracy and reliability.

Approved Methods:

**Rural:** For drainage areas on the rural roadway system the method most often used is taken from the U.S. Geological Survey Water Resources Investigations Report 92-4020, (Figure 1), dated 1992.

**Urban:** For drainage areas within the Urban System the method most generally used is the Rational Method. This method is limited to areas less than 200 acres (80 hectares). See Intensity Duration Frequency curves - Appendix V-03 C.

Other Methods:

- FHWA Method (Figure 2)
- “Hydrology Manual for North Dakota” published by the U.S. Department of Agriculture Soil Conservation Service (April 1979)

The Soil Conservation Service has been renamed Natural Resources Conservation Service (NRCS)

- Suitable hydrograph methods may be used for routing calculations to decrease peak flows, after the peak flow has been determined.

## Appendix V-01A

**HIGHWAY CLASSIFICATION CRITERIA - DESIGN FLOOD FREQUENCY**

The following flood design frequencies and design conditions are standard criteria for development of stream crossing locations with respect to highway classification.

FACILITY	STATE						COUNTY	
	URBAN SYSTEM		**RURAL SYSTEM				RURAL SYSTEM	
	REGIONAL	URBAN ROADS	PRINCIPAL ARTERIAL		MINOR ARTERIAL	MAJOR COLLECTOR	MAJOR COLLECTOR	OFF SYSTEM
			INTERSTATE	OTHER				
Structures (Bridges & RCB's)	25 years	25 years	50 years	50 years	50 years	25 years	25 years ***	15 years ***
Culverts (Mainline)	25 years	25 years	50 years	25 years	25 years	25 years	25 years ***	15 years ***
Storm Drains	*10 years	*5 years	10 years	10 years	10 years	10 years	-----	-----
Storm Drains (Underpasses)	*25 years	*25 years	50 years	25 years	25 years	25 years	-----	-----

\* Discharges are computed using the rational method.

\*\* Discharges computed in rural design most often are based on the USGS Report 92-4020.

\*\*\* Design frequencies may be reduced to 15 and 10 years respectively with adequate overflow section, or meet backwater requirements for adopted flood zone.